Two new species of *Garra (Teleostei–Cyprinidae)* from the Arabian peninsula

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Introduction

Continued interest in speleology in Oman has led to the discovery of yet another hypogean, but in this case microphthalmic, species of the cyprinid genus *Garra* from an extremely isolated sink hole in the Jabal Qara mountains of Oman. In the course of comparing this new species with its congeners, using the recent revision of Krupp (1983), the discovery of more specimens of Krupp's '*Garra*: incertae sedis (1)' enabled a second new species to be described. In all, eight species of *Garra* are now known from the Arabian peninsula.

Garra dunsirei sp. nov.
(Fig. 1)

The first four specimens received (BMNH 1984.3.6: 577–580) were collected by Mr A. Dunsire and Mr D. Green on 16 May 1980, but were in too poor a condition to be used for description. A further consignment of 19 live specimens (13 of which were still alive at the time of writing, July 1985) was collected by Mr D. Maclelland on 26 February 1983.

HOLOTYPE. BMNH 1984.3.6: 571, 68 mm SL; Tawi Atair (17°06′N, 54°34′E) in the Jabal Qara (variously Jabal Samhan) mountains, Dhofar, Oman.

PARATYPES. BMNH 1984.3.6: 572–576, 34–49 mm, same data as holotype.

LOCALITY. The fishes were caught in a pool in a side passage 200 m down the sink hole shown in Plates 1 and 2. The surface drainage is southwards to the Arabian Sea. The significance of the drainage direction and the isolated of the locality will be discussed below.

DESCRIPTION. The description is based on the holotype and five paratypes (34–68 mm SL), all of which were radiographed. Additionally two of the first four specimens (1984.3.6: 577–580) were cleared and stained with alizarin. All measurements are expressed as a percentage of the standard length. Because the sample is so small, the measurements of the holotype are included in the range as well as being given in parentheses.

MORPHOMETRIC DATA. Body depth $\bar{x}=22{\cdot}9$, range $=21{\cdot}4$–$23{\cdot}8$ (23·8); head length, $\bar{x}=27{\cdot}3$, range $=25{\cdot}0$–$30{\cdot}3$ (25·0); eye diameter $\bar{x}=3{\cdot}3$, range $=2{\cdot}8$–$3{\cdot}7$ (3·7); interorbital width $\bar{x}=9{\cdot}4$, range $=8{\cdot}2$–$10{\cdot}0$ (8·8); pectoral fin length $\bar{x}=20{\cdot}2$, range $=18{\cdot}8$–$21{\cdot}4$ (19·3); caudal peduncle length $\bar{x}=13{\cdot}7$, range $=12{\cdot}0$–$16{\cdot}0$ (14·7); caudal peduncle depth $\bar{x}=10{\cdot}1$, range $=9{\cdot}2$–$11{\cdot}4$ (10·3); anterior barbel length $\bar{x}=4{\cdot}2$, range $=3{\cdot}7$–$4{\cdot}5$ (3·7); posterior barbel length $\bar{x}=3{\cdot}5$, range $=2{\cdot}2$–$4{\cdot}0$ (2·6); dorsal fin height $\bar{x}=23{\cdot}1$, range $=22{\cdot}2$–$23{\cdot}8$ (22·8); mental disc maximum length $\bar{x}=7{\cdot}4$, range $=6{\cdot}5$–$8{\cdot}8$ (6·5); mental disc maximum width $\bar{x}=7{\cdot}3$, range $=7{\cdot}1$–$8{\cdot}1$ (7·2); distance between snout and anus $\bar{x}=76{\cdot}6$, range $=73{\cdot}5$–$78{\cdot}5$ (74·4); distance between snout and anal fin origin $\bar{x}=80{\cdot}9$, range $=77{\cdot}9$–$83{\cdot}6$ (78·7); distance between snout and pelvic fin origin $\bar{x}=60{\cdot}5$, range $=58{\cdot}8$–$63{\cdot}3$ (59·1); distance between snout and dorsal fin origin $\bar{x}=53{\cdot}0$, range $=45{\cdot}9$–$55{\cdot}9$ (51·5).

The body shape and details of the mental disc are shown in Figs 1 and 2a. The abdomen of the holotype has collapsed, creating an uncharacteristic flat-bellied appearance. The eyes are very small and not visible in ventral view. The mental disc is approximately circular. In the smallest specimen (34 mm SL), only the posterior margin of the disc is free, but as the fish grows, the rest of

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Plate 1. The sink hole at Tawi Atair.

Plate 2. A close-up of the arrowed area in Plate 1 to indicate the size of the sink hole.

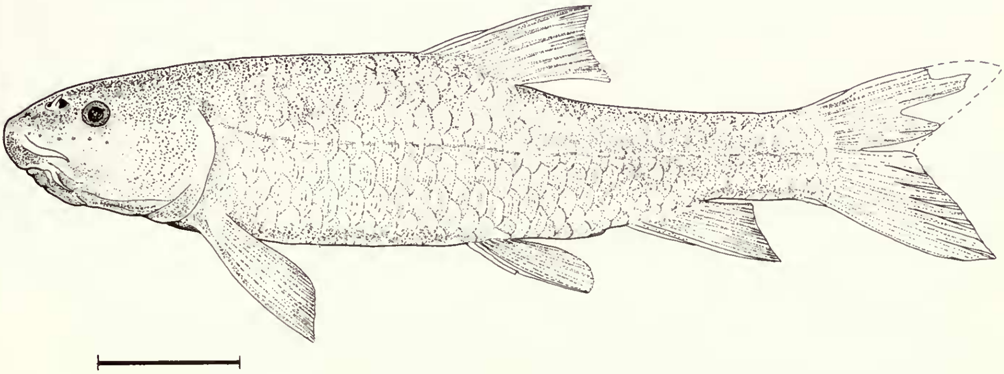

Fig. 1. *Garra dunsirei* Holotype. Scale = 10 mm.

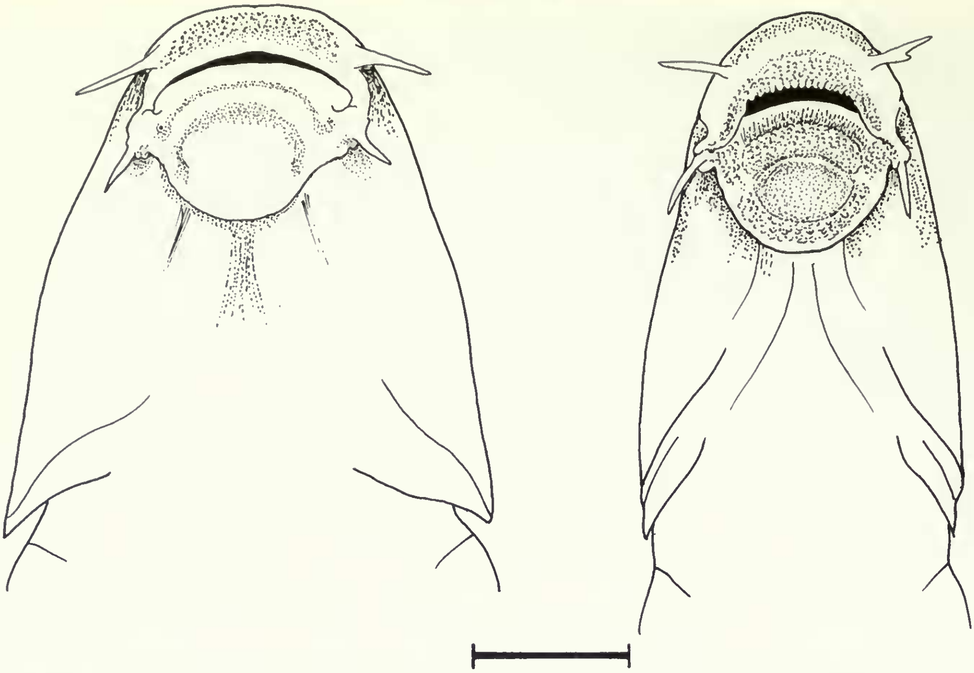

Fig. 2. Ventral views of the heads of a. *Garra dunsirei* and b. *Garra lautior*. Scale = 5 mm.

the rim becomes free. The papillae are scarcely developed, the papillar bed being only just differentiated in a specimen of 50 mm SL (Fig. 2a). Only on the holotype are the papillae well formed. The size and extent of the papillae are less than in all other *Garra* in the region.

None of the specimens, alive or preserved, has tubercles on the snout, although a 39·5 mm SL specimen is a gravid female.

SQUAMATION. The scales are less well developed than those of the hypogean population of *Garra barreimiae* (Banister, 1984) which, although thinner than the scales of epigean populations, are scarcely less extensive. In *Garra dunsirei* the scales are as deep as, or deeper, than long and although they fill the scale pocket vertically, they often fail to reach the posterior edge of the pocket. A scale and its pattern of striations is shown in Fig. 3. Scales of the holotype have eleven 'growth' rings. It is not known if these represent annual or seasonal spawning marks or are the result of growth changes caused by food availability. Food only comes into the cave during the annual rains. The scales of the ventral region of the body are severely reduced or absent. In the lateral line series there are 34(f2), 35(f3) or 36(f1) scales. There are $3\frac{1}{2}$(f6) scale rows from the dorsal fin base to the lateral line and $2\frac{1}{2}$(f3) or $3\frac{1}{2}$(f3) scale rows from there to the pelvic fin base. On the two specimens on which a count was possible there are $6\frac{1}{2}$ scale rows from the lateral line to the ventral mid-line. Twelve (f6) scale rows encircle the least circumference of the caudal peduncle.

VERTEBRAE. Radiographs revealed the presence of 32(f3) or 33(f3) vertebrae, excluding those forming the Weberian mechanism. It was difficult to identify with certainty the first caudal vertebra but there appear to be 18(f2) or 19(f4) abdominal vertebrae. There are 14(f2) or 15(f4) pairs of ribs.

Characteristic of this species is the most unusual change of shape of the neural arches and spines below the dorsal fin. In all the other Arabian peninsular *Garra* species and in all other *Garra* species investigated the neural spines are shorter in this region, but of the same general configuration and angle as the other neural spines (Fig. 9). In *Garra dunsirei* (Fig. 4) the neural spines are bent sharply back and come to lie almost in parallel with the axis of the centrum.

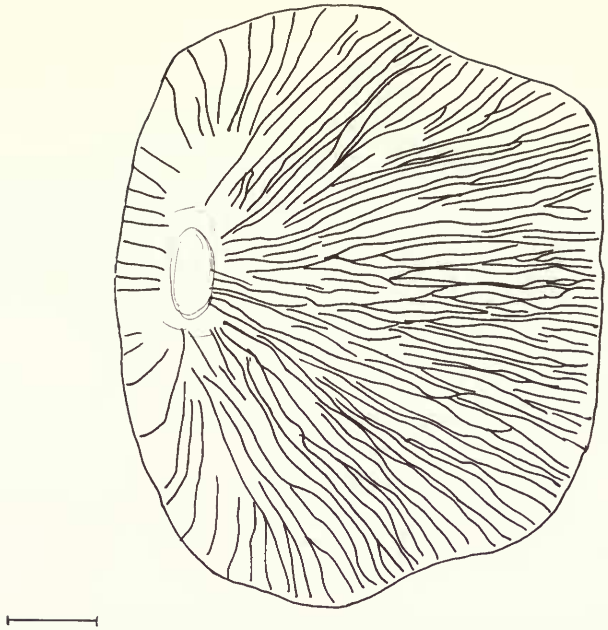

Fig. 3. A scale from the row above the lateral line of the holotype of *Garra dunsirei*. Scale = 0·5 mm.

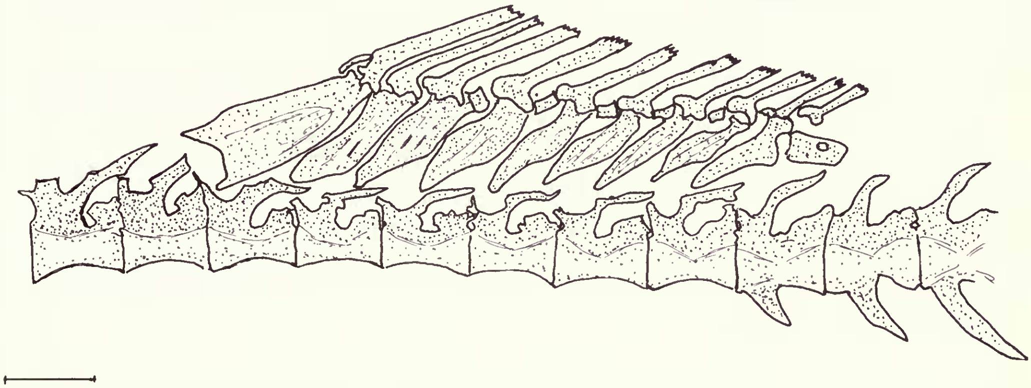

Fig. 4. *Garra dunsirei*. The vertebral column below the dorsal fin to show the unusual profile of the neural spines. For clarity the ribs are omitted. Scale = 1 mm.

FINS. The dorsal fin has only 3(f6) unbranched and 7(f5) or 8(f1) branched rays. The foremost unbranched ray is minute and only visible in a radiograph or an alizarin preparation. The anal fin has 3 unbranched and 5 branched rays (f6). The first unbranched ray is again minute and not visible externally.

GILL RAKERS. The gill rakers are small in size and few in number. There are 6(f2) or 7(f2) on the lower limb of the first gill arch. They could not be counted in the two smallest specimens.

PHARYNGEAL BONES AND TEETH. The pharyngeal teeth number 2.4.5–5.4.2 (Fig. 5). The five posterior teeth of the innermost row are thin and have hooked crowns, quite unlike those typical of other *Garra* species from the Arabian peninsula (see Krupp, 1983: figs 23, 27, 40).

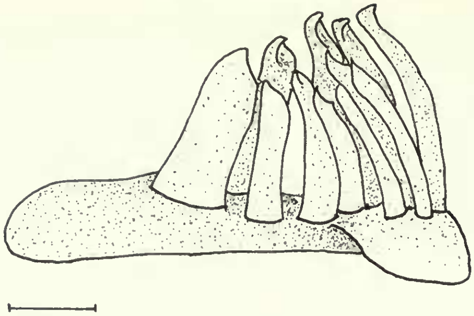

Fig. 5. Left pharyngeal bone of *Garra dunsirei*. Scale = 1 mm.

COLORATION. Alcohol preserved specimens are uniform pale, yellowish grey. The ventral surface is only slightly paler than the rest of the body. There are traces of dark pigment near the anterior edge of the pectoral fins, on the dorsal edge of the dorsal fin membrane as well as near the base of the dorsal fin (the last being the typical *Garra* markings). Other fins are colourless.

Living fishes are a dirty white, slightly more heavily dusted with dark pigment dorsally. The cheeks and operculum reflect greenish-gold. The post-opercular spot is inconspicuous but the red of the blood in the gills is clearly visible through the adjacent notch.

ETYMOLOGY. This species is named in honour of the collector, Mr Andy Dunsire, who has encouraged so many people to search for subterranean fishes, as well as collecting such fish himself in isolated and hazardous regions.

NOTES ON LIVING SPECIMENS. The fishes swim slowly, but continually, usually in a slightly head down position. When resting, they are indifferent to their orientation provided that their ventral surface is in contact with a solid object. They stay near the bottom of the aquarium, very rarely approaching the surface even to take food.

In these aspects they contrast markedly with the blind, hypogean population of *Garra barreimiae* which swims rapidly and swarms at the surface on the introduction of food (Banister, 1984).

Garra dunsirei shows no preference for either light or dark conditions, although a strong light beam shone on an individual will cause it to jerk away after one or two seconds. After that, however, the fishes will come and investigate a localised illuminated patch on the substrate.

DISTRIBUTION AND RELATIONSHIPS. Of particular interest is the geographical isolation of *Garra dunsirei* from its congeners. In fact, no primary freshwater fishes have been recorded from this area of Dhofar, the closest natural populations being nearly 400 miles away at Tarim in the Wadi Hadramut to the west and also some 450 miles to the northeast in the Omani Jabal Akhdar. The drainage of this part of the peninsular coast is a series of isolated wadis carrying the run-off due south from the Jabal Qara range to the Arabian sea. On the north side of the Jabal Qara is an interlinked series of wadis that in wetter times would have carried water northwards into the extensive lake or lake system that occupied the site of the Rub al Khali. Krupp (1983) points out that the Jabal Qara range is part of an ancient feature whose presence caused the formation of the internal drainages. Although the internal basin would have permitted fish dispersal northward from Jabal Qara, whether or not it allows fishes from the north access to the streams south of Jabal Qara is unknown. It might be possible to determine the hydrological affinities of this isolated water source were the phylogenetic relationships of *Garra dunsirei* known. For the moment, therefore, neither the hydrological affinities of the sink hole nor the phylogenetic relationships of *Garra dunsirei* can be determined.

DIAGNOSIS. This species can be characterised by the late development of the papillar beds on the mental disc, the papillar bed being only just differentiated at 50 mm SL; also the small eye diameter ($\bar{x}=3{\cdot}3$) and the highly unusual shape of the neural spines below the dorsal fin (see Fig. 4 and p. 62).

Garra lautior sp. nov.

The recognition of this species stems from Krupp (1983: 615) who described six specimens from the Wadi Hadramut as '*Garra*: incertae sedis (1)' but was reluctant to base a species on such a small sample. A search through the collections of the British Museum (Natural History) revealed 13 more specimens.

HOLOTYPE. BMNH 1976.4.7: 398, 74 mm SL from the Qasam area, Wadi Hadramut, Yemen, coll. King-Webster.

PARATYPES. BMNH 1976.4.7: 399–404, 64–74 mm SL (other details as above); 1976.4.7: 647–648, 71 & 75 mm SL (other detals as above); 1976.4.7: 377–378, 61 & 74 mm SL: (other details as above); 1976.4.7: 645, 80 mm SL from Al-Ghurf, Wadi Hadramut, coll. King-Webster; BMNH 1976.4.7: 366 79 mm SL, from Gheil Umar, Wadi Hadramut, coll. King-Webster.

DESCRIPTION. The description is based on the holotype as 12 paratypes (61–80 mm SL). The measurements are expressed as a percentage of the standard length those of the holotype are included in the range also also given separately in parentheses.

MORPHOMETRIC DATA. Body depth $\bar{x}=22{\cdot}3$, range$=20{\cdot}2$–$25{\cdot}0$ (22·3) ($n=8$); head length $\bar{x}=22{\cdot}4$, range$=21{\cdot}6$–$23{\cdot}4$ (21·6); eye diameter $\bar{x}=4{\cdot}8$, range$=4{\cdot}0$–$5{\cdot}4$ (5·4); mouth width $\bar{x}=5{\cdot}7$, range$=4{\cdot}4$–$6{\cdot}6$ (6·1); pectoral fin length $\bar{x}=19{\cdot}4$, range$=18{\cdot}7$–$21{\cdot}5$ (19·3); caudal peduncle length $\bar{x}=17{\cdot}1$, range$=15{\cdot}2$–$20{\cdot}0$ (15·9); caudal peduncle depth $\bar{x}=8{\cdot}6$, range$=7{\cdot}7$–$9{\cdot}4$ (9·3); anterior barbel length $\bar{x}=2{\cdot}6$, range$=1{\cdot}3$–$3{\cdot}2$ (3·0); posterior barbel length $\bar{x}=2{\cdot}0$, range$=1{\cdot}5$–$3{\cdot}7$ (1·9); dorsal fin height $\bar{x}=24{\cdot}8$, range$=22{\cdot}9$–$28{\cdot}1$ (25·5); mental disc maximum length $\bar{x}=5{\cdot}4$, range$=4{\cdot}7$–$6{\cdot}3$ (5·5); mental disc maximum width $\bar{x}=7{\cdot}0$, range$=5{\cdot}7$–$7{\cdot}7$ (7·3); distance between snout and anus $\bar{x}=71{\cdot}4$, range$=66{\cdot}6$–$75{\cdot}0$ (70·2); distance between snout and anal fin origin $\bar{x}=74{\cdot}3$, range$=69{\cdot}3$–$77{\cdot}0$ (72·2); distance between snout and pelvic fin origin $\bar{x}=50{\cdot}6$, range$=47{\cdot}9$–$52{\cdot}6$ (50·4); distance between snout and dorsal fin origin $\bar{x}=45{\cdot}2$, range$=43{\cdot}2$–$46{\cdot}8$ (43·5).

The body has a characteristic, streamlined shape (Fig. 6 and Krupp, 1983: fig. 30). From the pointed snout, the dorsal profile rises smoothly to the insertion of the dorsal fin. Behind the dorsal fin, the trunk diminishes in depth, terminating in a slender caudal peduncle almost exactly half as deep as long. In five specimens the abdomen had collapsed, so a reliable body depth measurement could not be taken. In ventral view, the upper lip is thick and has many small papillae. The shape of

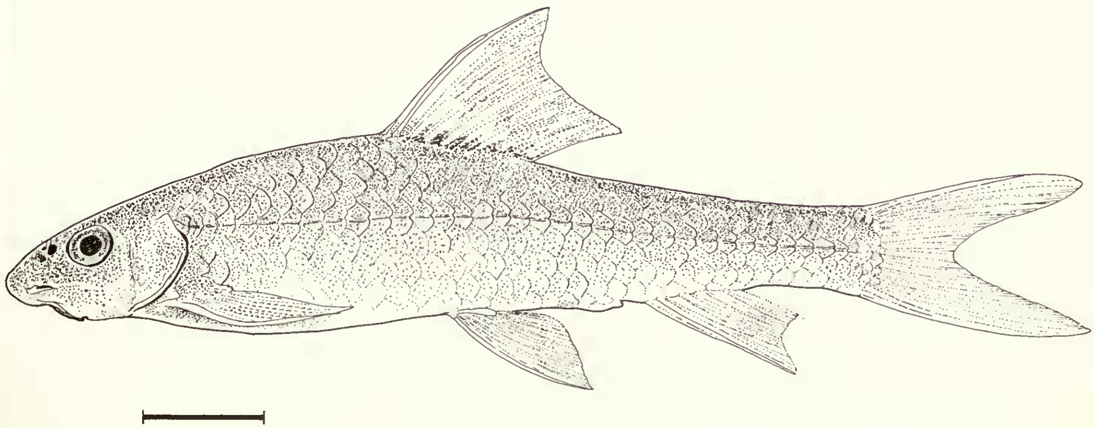

Fig. 6. *Garra lautior*. Holotype. Scale = 10 mm.

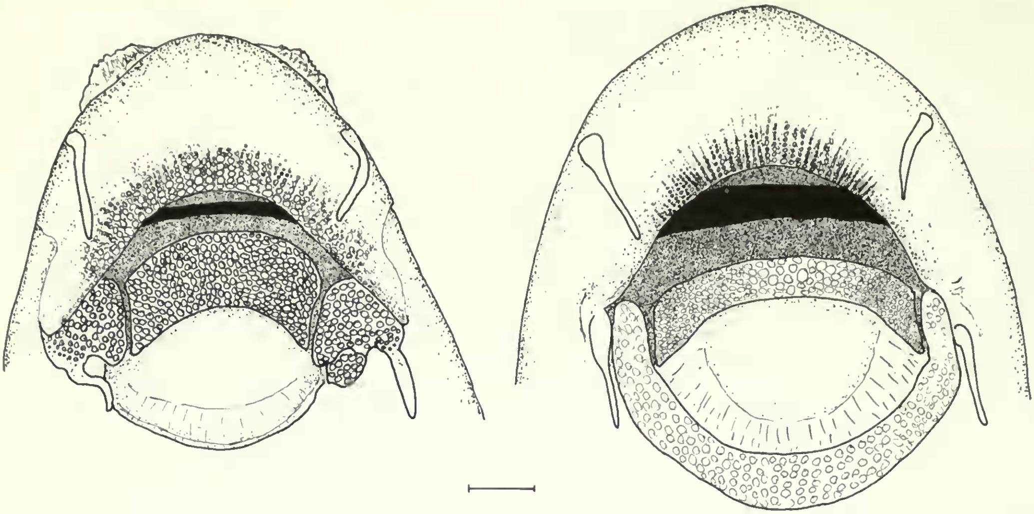

Fig. 7. Details of the distribution of papillae on the frenum, lips and disc of (left) a paratype of *Garra mamshuqua* (74 mm SL ex 1976.4.7: 381–387), and (right) a paratype of *Garra lautior* (74 mm SL ex 1976. 4.7: 399–404) Scale = 0·1 mm.

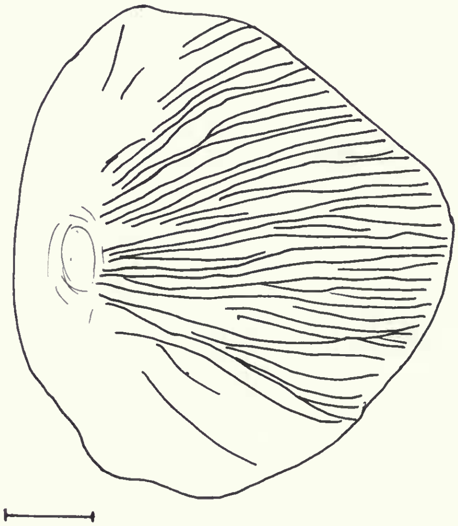

Fig. 8. A scale from the row above the lateral line of *Garra lautior*. Scale = 0·5 mm.

the disc and the disposition of the papillar beds are shown in Figs 2 & 7B. None of the specimens has any tubercles on the head although both mature males and females are present in the sample (see below).

The small size range of the specimens available was insufficient to establish any marked instances of allometric growth.

SQUAMATION. The scales are well developed and slightly lobate. A scale and its striations are shown in Fig. 8. Only two poorly defined growth rings were discernible. In the lateral line series there are 32(f3), 33(f4), 34(f4) or 35(f2) scales. From the dorsal mid-line to the lateral line there are $3\frac{1}{2}$(f9) or $4\frac{1}{2}$(f3) scales and from the lateral line to the pelvic fin base $3\frac{1}{2}$(f13) scales. In front of the anal fin the ventral surface is scaleless. There are 12(f13) scale rows around the least circumference of the caudal peduncle.

VERTEBRAE. In the nine specimens radiographed there are 27(f2), 28(f3), 29(f3) or 30(f1) vertebrae, excluding those comprising the Weberian mechanism. The abdominal vertebrae number 12(f3) or 13(f6) (allowing for the difficulty in identifying the first caudal vertebra). The neural spines below the dorsal fin pterygiophores display the normal alignment and reduction in size of most *Garra* spp (Fig. 9) in contrast to the unique condition in *Garra dunsirei* (Fig. 4).

In all the other species of *Garra* radiographed: viz *G. mamshuqua* Krupp, 1983, *G. barreimiae* Fowler & Steinitz, 1956, *G. sahilia* Krupp, 1983, *G. tibanica* Trewavas, 1941, and *G. dunsirei*, there are 4 interhaemal spine spaces corresponding to the anal fin pterygiophores (Fig. 10), but in *G. lautior* only three interhaemal spine spaces do so correspond (Fig. 11). No particular significance is attached to variations in the shape of the last anal fin pterygiophore. There are 14(f7) or 15(f2) pairs of ribs.

GILL RAKERS. The gill rakers are small, hooked and number 11(f1), 12(f1), 13(f3), 14(f1), 15(f3), 16(f1) and 17(f1) on the lower limb of the first gill arch.

PHARYNGEAL BONES AND TEETH. The pharyngeal teeth number 2.4.5–5.4.2 (Fig. 12). The crowns have shallow spoon-edged depressions, the depression being most sharply edged in newly replaced teeth.

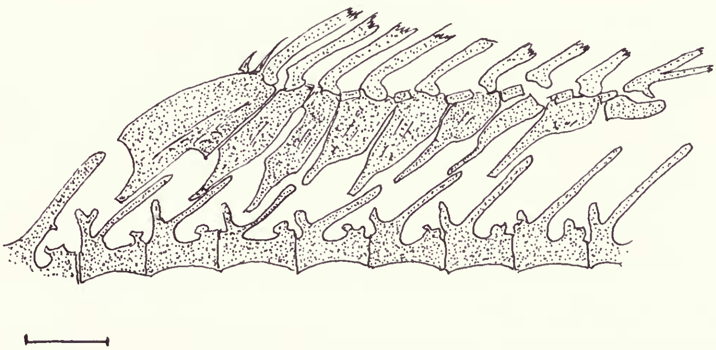

Fig. 9. The vertebral column below the dorsal fin of *Garra lautior* to show the shape of the neural spines. Scale = 1 mm.

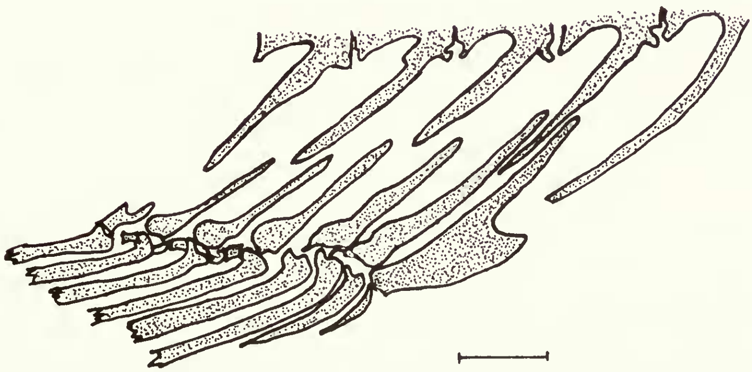

Fig. 10. The anal fin pterygiophores of an unregistered BMNH specimen of *Garra mamshuqua*, 54 mm SL, to show their opposition to four interhaemal spaces. Scale = 1 mm.

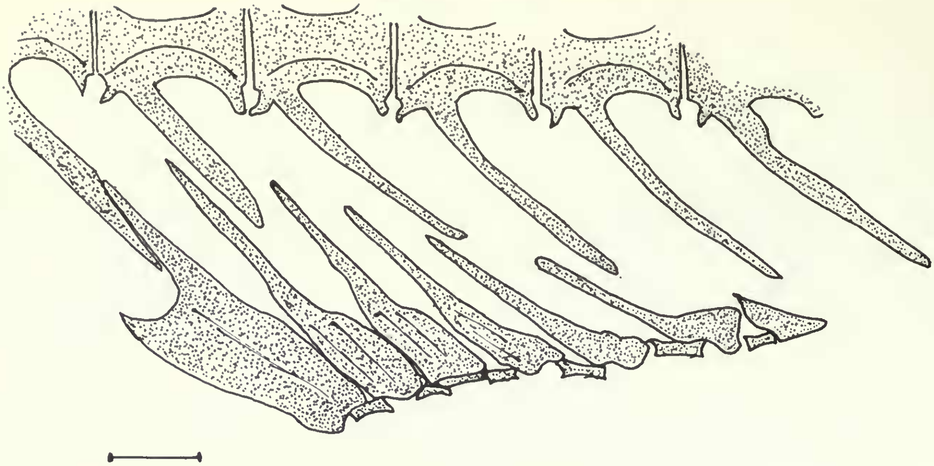

Fig. 11. The anal fin pterygiophores of a specimen of *Garra lautior* (unregistered) to show their opposition to only three interhaemal spaces. Scale = 1 mm.

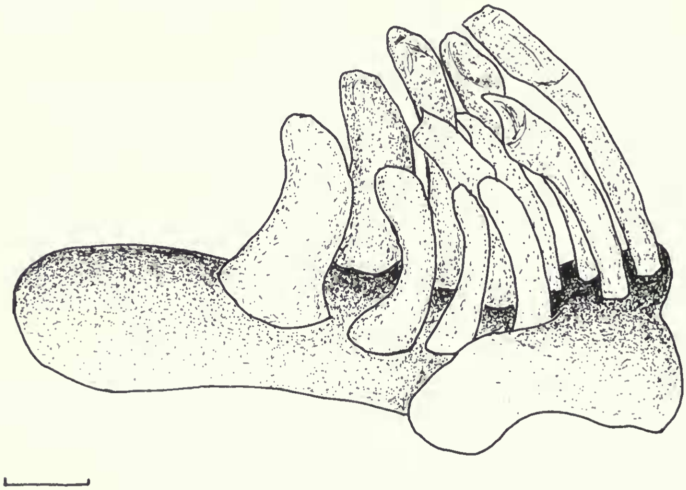

Fig. 12. Left pharyngeal bone of the holotype of *Garra lautior*. Scale = 0·5 mm.

Coloration. Alcohol preserved specimens are a uniform sandy brown, darker dorsally. The post-opercular spot is a deeper brown, but the *'Garra'* marks at the base of the dorsal fin membrane are not especially conspicuous. The fin membranes are clear.

Distribution. This species is known only from localities within the Wadi Hadramut drainage, Yemen.

Etymology. The trivial name is the comparative of *lautus*, the Latin for smart or neat and alludes to the neat, streamlined appearance of the fish.

Diagnosis. *Garra lautior* is sympatric only with *Garra mamshuqua* (see below). Although the two species are somewhat similar in body shape, *Garra mamshuqua* can be distinguished by the presence of tubercles on the snout, the very conspicuous *'Garra'* marks on the dorsal fin and behind the operculum and the different disc shape (Fig. 2b & 7b). Very small specimens can be most easily separated on the greater intensity of the post-opercular spot in *Garra mamshuqua*.

TUBERCLES. Tubercles on the snout are often called nuptial or breeding tubercles (e.g. Wiley & Collette, 1970) or multicellular horny tubercles (Roberts, 1982). The latter author points out that they may occur in both sexes as well as being present before the onset of sexual maturity in *Labeo* species and the homalopterids. In *Garra mamshuqua,* the tubercles are present in both males and females at all stages of sexual maturity and first appear in specimens of 27 mm SL (e.g. in BMNH 1967.4.7: 407–418). It seems probable therefore that in *Garra mamshuqua* the tubercles do not have a solely sexual or reproductive function.

A hydrodynamic function was suggested by Reid (1978) for their occurrence in *Labeo,* since fishes from faster flowing waters had more and larger tubercles than those from quiet waters. The localities where the smooth *Garra lautior* and the tuberculate *Garra mamshuqua* are sympatric were described by the collector (original letter in the BMNH Fish Section archives) as 'a clear stream with stony shallows and deep holes' (Gheil Umar), and also an 'isolated muddy pot-hole below a dam' (Al-Ghurf). Such scanty and seemingly inconsistent information adds nothing to Reid's hydrodynamic hypothesis.

Although the function of the tubercles is not known, it does seem in this case that their presence can be used as a sound diagnostic character to distinguish these two sympatric species. However, it is not suggested that the presence or absence of tubercles is diagnostic for other species.

Discussion

Krupp (1983) also recorded both *Garra tibanica* and *Garra sahilia* from the Wadi Hadramut. *Garra tibanica* was included as a member of the Hadramut fauna solely on specimens collected by Scortecci at Bir el Manzil (14°32′N, 48°51′E *fide* Krupp). Scortecci's Bir el Manzil is shown on the map in Balletto & Spano (1977), which is concerned with the Scortecci expedition and is approximately 14°30′N, 44°30′E or well to the west of the Hadramut.

The Wadi Hadramut record of *Garra sahilia* was based on four fishes, two from Sayun (BMNH 1980.4.24: 8,9) and two from nearby Shibam (BMNH 1980.4.24: 6,7). The latter specimens were identified by Krupp but not listed in his 1983 paper. The four fishes do not correspond to the description, especially in having much longer barbels and the anus closer to the anal fin than in *Garra sahilia.* However, their poor condition precludes confirmation of Krupp's specific determination.

There are some difficulties in establishing which specimens of *Garra sahilia* are types. Krupp (1983: 601) lists 63 specimen (BMNH 1976.4.7: 419, 420–425; 1951. 5.9: 12–65 and 1944.4.3: 1–10) as paratypes but used only 25 specimens in his description. Presumably, thc 63 listed paratypes included the 24 actually described (although the largest specimen in his sample, 100·5 mm SL BMNH 1940.2.15: 12–18 was used in the description but not designated a paratype).

Although twice as many *Garra lautior* specimens were available to me than to Krupp, in most respects our descriptions are similar. However, there is substantial discrepancy in our scale counts around the caudal peduncle. In the 13 specimens used here (6 of which were those used by Krupp) I could count only 12 scales, whereas Krupp gives 14(f1) or 16(f5). A similar discrepancy occurs with the same count in *Garra buettikeri* Krupp, 1983, Krupp giving 18(f2) or 20(f18) as the diagnostically high circumpeduncular scale count, whereas in the six BMNH specimens he used in his description I count only 16(f2) or 18(f4) scales. In Krupp's fig. 21 twenty scales would be too many, unless the squamation in the specimen illustrated was unusually asymmetrical. Although Krupp did not indicate how he made his counts I can imagine only one way of counting the number of scale rows around the least circumference of the caudal peduncle. It seems unwise, therefore, to attribute diagnostic significance to this particular meristic feature. No attempt is made in this paper to produce a key to the *Garra* species of the Arabian peninsula. Even a cursory glance at the means and ranges of any particular morphometric or meristic feature used here, in Krupp (1983), in Banister & Clarke (1977) and in many other papers shows that the similarity of means and the extensive overlaps in range usually precludes the use of such characters in a key. Even if the eight peninsular species were initially subdivided by drainage regions (giving groups of 3, 2, 2 and 1) a key based on morphometric and meristic characters would not infallibly separate the sympatric species. The major diagnostic features are regrettably very difficult to quantify. At the moment the most useful characters are the overall body shape, the shape of the mental disc and the distribution of papillae thereon, and the colour pattern. Although details of the mental disc serve to distinguish species, based on the samples available, the variation in at least one species, *Garra tibanica* (Balletto & Spano, 1977: fig. 6) makes one wonder whether it will remain useful when more populations are discovered.

Krupp 1983: 603–615 provided a useful list of all the specimens he examined. There are, however, some confusions in the BMNH register numbers in his list and these and some other errors are corrected below.

Garra sahilia sahilia (p. 603)
Sample No. 10 for Wadi Abd read Wadi Anad 44°50′E, 13°17′N
No. 14 for 1976.4.7: 443–460 read 1976.4.7: 460
No. 15 for 1910.1.28: 1–3 read 1870.1.28: 1–3

Garra sahilia gharbia (p. 604)
Sample No. 5 for 1976.4.7: 646–354 read 1976.4.7: 346–349

Garra tibanica tibanica (p. 608)
Sample No. 5 for 1976.4.7: 443–460 read 1976.4.7: 443–459
No. 11 for 1952.5.7: 13–18 read 1952.5.7: 13–17
No. 17 for 1976.4.7: 346–356 read 1976.4.7: 350–354

Garra incertae sedis (p. 615)
Sample No. 1 for 1976.4.7: 374–377 read 1976.4.7: 377
No. 3 for 1976.4.7: 380–406 read 1976.4.7: 380–396

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